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ABSTRACT

Recent studies have suggested that requiring written responses as part of programed instruction format may have a negative effect on learning while more difficult responses may have the effect of holding interest and increasing achievement. To further explore the effect of response mode on rates of learning, a study was designed which compared the effects of: overt response; optional response; covert response; and implicit (reading) response. Four programed booklets, one representing each response mode were prepared and administered randomly in two eighth grade classrooms. Pre- and posttests were used to assess amount learned and records were kept for time required to complete lesson. A learning efficiency index was calculated, and the implicit reading response mode proved the most efficient. (EMH)

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FURTHER EXPERIMENTAL EVIDENCE ON RESPONSE MODES IN AUTOMATED INSTRUCTION

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FURTHER EXPERIMENTAL EVIDENCE ON RESPONSE MODES IN AUTOMATED INSTRUCTION

Introduction

Recent studies (e.g., Evans, Glaser & Homme, 1960; Silverman & Alter, 1960) have shown a need to examine the efficacy of using overt written responses in continuous discourse programs of the type developed by Skinner (1958). These studies have failed to show that written responses are beneficial to learning and suggest that the requirement to write a response may, in fact, be less effective in achieving learning than reading the same material in programmed format.

Aside from the direct question of which mode of responding to programmed material produces a greater amount learned, there are some practical considerations that appear relevant. A learning procedure which includes a recording of responses provides the advantage of allowing for an evaluation of learning progress and the consequent possibility of modifying the presentation of subsequent material to adjust to a student's progress. On the other side, constructing responses takes time, especially if the response is written out. This additional time spent tends to decrease the efficiency of the learning process.

A previous study under this contract (Goldbeck, 1960), using independent items rather than continuous discourse, investigated the possibility that the difficulty in response making would affect the value of requiring overt written responses, on the assumption that the value of overt response lies in maintenance of active concentration on the task. Thus, requiring of the student only easily made overt responses may reduce the

"activeness" of responding, whereas increasing response difficulty may create greater active responding and, hence, increased learning (cf. Goldbeck and Briggs, 1960). This assumption was supported by the data from a test of the amount learned. However, efficiency scores obtained by considering time spent on the learning matter showed reading to be most efficient at all difficulty levels used, with covert second in efficiency, and overt least efficient.

The possibility that a moderately difficult program may show a greater advantage for overt responses, as well as being a more generally effective learning procedure, led to the use of such a program of continuous discourse material in the present study to investigate response mode differences. It must be recognized that the concept of response difficulty and the associated active response pattern have not yet been systematically related to specific dimensions of cueing and prompting techniques (cf. Briggs, 1960). The translation of "response difficulty" from independent frames to continuous discourse frames involves even more complexities. Nevertheless, the notion appears important enough to explore some of the possibilities for producing a continuous discourse program with more active response characteristics and to examine the generality of previous response mode findings with such a program.

The response modes used in the present study were the overt written response, the thinking or covert response, and the reading or implicit response, as in the previous study using independent items. The instructions for the covert response condition were modified, however, to emphasize that some covert response should be made, rather than allowing the subject to decide whether he could think of a correct response as in the previous study.

This change was made in the definition of the covert response mode condition, because the previous study indicated that a large proportion of subjects habitually neglected the attempt to think of a response. A fourth response mode condition was included in the collection of data. This response mode allowed the subject to exercise an option either to use an overt written response when he was "sure" of being correct or to make no response when not sure.

The four response mode conditions may be ordered according to the amount of response activity explicitly requested by the instructions for the learning material formats. This order, in decreasing amount of response activity, would be the following: overt response, option response, covert response, implicit (reading) response. The pattern of responding cannot be described completely, however, by the instructions to respond. One consideration relevant to response pattern is experience with the learning procedure. Motivation and interest in the method may change with time spent using it, and the manner of using the method may change with practice on the learning material and with the experience of taking a test covering the learning material. In the present study, therefore, the experimental program was preceded by a short program, in which the response mode corresponded with that used for the experimental program, and a brief quiz on the practice program learning material.

Method

Material

Experimental Program and Quiz.- The learning material consisted of 32 frames on the topic of light, based on the initial portion of an auto-instructional program developed by Klaus, et al (1960). The original program

was modified in several respects to achieve the increased difficulty and the resulting responding pattern necessary for the experimental purposes. Some frames were deleted; some direct prompts within a frame were moved to earlier frames; other direct prompts were replaced by less direct cues; some response terms were changed; and the order and composition of frames were revised. The modified program of 32 frames, in which a frame had from one to four response terms, contained a total of 51 response terms.

Four different types of programmed learning booklets were prepared, one for each of the four response mode conditions: overt response, option response, covert response, and implicit (reading) response. The content and format for the overt, option, and covert response booklets were the same, except for the cover page on which there was a brief summary of instructions for the particular response condition.

Each frame consisted of a single paragraph printed on a separate 11 x 8½-inch page. A frame contained one or more blanks for S to supply the missing word or phrase either by writing in every blank, in the case of the overt response condition; by writing in selected blanks, in the case of the option response condition; and by thinking of the word or phrase, in the case of the covert response condition. The correct words or phrases for the blanks were printed on the right side of the page, in line with the appropriate blank, and were covered by a slip of gray paper. This cover slip was attached at the top of the page and could be lifted by S, after responding as directed, to show the correct words or phrases.

In the reading or implicit response booklet, the frames contained no blanks and no words or phrases covered by the gray slip of paper. Any word or phrase which was the occasion for a blank in the other response mode

booklets was printed in the context of the frame, as in conventional reading matter, with the word or phrase underlined. Fight of the frames in the other booklets contained some underlining in addition to the blanks. This underlining also was included in the corresponding implicit response mode frames. The cover page of the learning booklets was color-coded for response mode: white for overt, pink for option, blue for covert, and yellow for reading.

The test developed to measure the amount of learning resulting from the programmed material consisted of 29 items assembled into a Quiz Booklet. Some of the items required a short one-part answer, and were given a scoring value of one. Other items required a two or three-part answer, and each part was given a scoring value of one. The remainder of the items required a yes-no recognition of a list of descriptive characteristics, and each characteristic was given a scoring value of one-half. The total possible score for the test was 41. The test was constructed with the aim of assigning score value homogeneously among the areas of learning content. Some of the test answers had been a "response" term in the learning material while others had not.

Instructions and Practice Program.- The general instructions and the specific instructions for all four response modes were prepared as a unit to be given to all Ss. The instruction pages were color coded so that all of the instruction pages for a given S were of the color that designated his response mode.

A practice program of 14 frames on the topic of mountain climbing was prepared in the same format as the experimental program on the topic of light. A short test of six items was prepared covering the learning material of the practice program. The instructions, practice program, and practice

test were assembled in one booklet labeled Instructions and First Lesson.

Subjects

Data were collected from a total of 62 subjects in two eighth-grade classes. Thirty-three subjects were in one class and 29 in the other. Both of the classes were of above-average ability, having been formed on the basis of school placement tests and scholastic achievement. The ability level of the two classes was comparable as measured by mean score on the reading portion of the School and College Aptitude Test ($t = .75$ for d.f. = 60).

Procedure and Design

The experiment was conducted concurrently in the two separate classrooms. The booklets containing the instructions, practice program and practice quiz for the four different response mode conditions were passed out in the classrooms, so that the relative sequence of the response mode conditions in any row of adjacent seats was overt, covert, option, and reading. This procedure resulted in an essentially random assignment of experimental conditions to Ss and it isolated Ss who wrote responses during learning, while insuring a close approximation to equal Ns in the experimental groups. The number of Ss assigned to the four experimental conditions in each class is shown here:

	Response Mode			
	Overt	Option	Covert	Reading
Class A	7	8	7	7
Class B	9	8	8	8

All Ss in a class read the general instructions and instructions specific to the response mode conditions from their booklets, while E read these instructions aloud.

The instructions made it clear which of the four response modes was to be used by S as indicated by the color code on his booklet. Ss were told that their performance would be evaluated primarily by their quiz score, but that their learning time would also be recorded. The final page of instructions, read silently by S, was a brief summary of the procedure for the particular response mode to be used by S.

All Ss in a class began the practice learning program at the same time, and each S proceeded through the program once at his own speed. There was no allowance to return to any frame for review. Nor was "looking ahead" permitted. When S finished the first program, he raised his hand to have the time recorded on the booklet; then he began the quiz on that material immediately. When S finished the quiz, he raised his hand again, to have the first booklet collected. This booklet, labeled Instructions and First Lesson, contained the instructions and the practice program and quiz. S was immediately given the booklet labeled Second Lesson-Light, and the time was recorded on this booklet. The brief summary of instructions was on the cover page for this booklet, with the cover page color-coded for the response mode. S proceeded through the learning program in the booklet in the same manner as in the practice program. When he finished the program, S raised his hand to receive the quiz booklet for the test covering the experimental program. The time was recorded on the quiz booklet at the beginning of the quiz and, again, when S raised his hand to have the quiz collected. S could not return to a page in the quiz booklet, once he had completed the page. As S completed the quiz, he was told he had completed the experiment and could read from a book which was available to keep him occupied while the others finished.

Results

Learning Response Difficulty

Scoring the 51 responses to the experimental learning program made by the 16 Ss in the overt response mode group gives some indication of the difficulty level for the program responses. These Ss averaged 84% correct responses during learning. It is also of interest that the 16 Ss in the option response mode group omitted an average of 12% of the responses and responded incorrectly to an average of 10% of the blanks, giving an average of 78% correct responses during learning.

These error rates cannot be meaningfully compared as indices of difficulty with those of the previous study involving independent items. One reason for this is that scoring was somewhat more liberal for the continuous discourse program (e.g., synonyms were accepted as correct) because grasping the correct idea was judged to be the relevant criterion, rather than naming a factual item. It is reasonable, however, to consider the present experimental program as presenting a relatively difficult level of responding when compared to typical Skinner-type programs.

Amount Learned

The measure of amount learned was obtained from the scores on the quiz covering the programmed learning on the topic of light. The quiz booklets were scored without knowledge of the experimental group to which S had been assigned. Answers to open-ended questions were scored as correct so long as S was judged to have grasped the meaning of the learning material as it was presented in the programmed instruction. One staff member scored all of the quizzes. In cases where there was some doubt concerning whether or not an answer was correct, two other staff members were consulted and

agreement among the three was reached.

Analysis of variance was used to test for differences among response modes and classes. Since there is a slight disproportionality in the number of cases in the cells of the double classification analysis, one analysis was performed on the quiz scores using a correction for disproportionate sub-class numbers (Snedecor, 1938) and another analysis was performed ignoring the disproportion. Inasmuch as negligible differences were found between the results of the two analyses, it was decided to report the analysis ignoring the slight disproportionality and to perform the remaining analyses in like manner.

Table 1 shows the analysis summary in which response mode and class differences fall short of significance at the .05 level of confidence.

Table 1

Analysis of Variance Summary for Quiz Score Data[1]

Source	d.f.	mean square	F
Response Mode	3	260	2.18
Class	1	438	3.68
R X C	3	72	--
Within	54	118	--

[1]Scores for this analysis were multiplied by a factor of 2 for ease of computation.

It is of interest to note that the difference between classes is fairly appreciable ($P < .10$). Since great effort was made to creat equivalent experimental conditions for the two classes, it is assumed that this difference is attributable to sampling error or a difference in the habitual

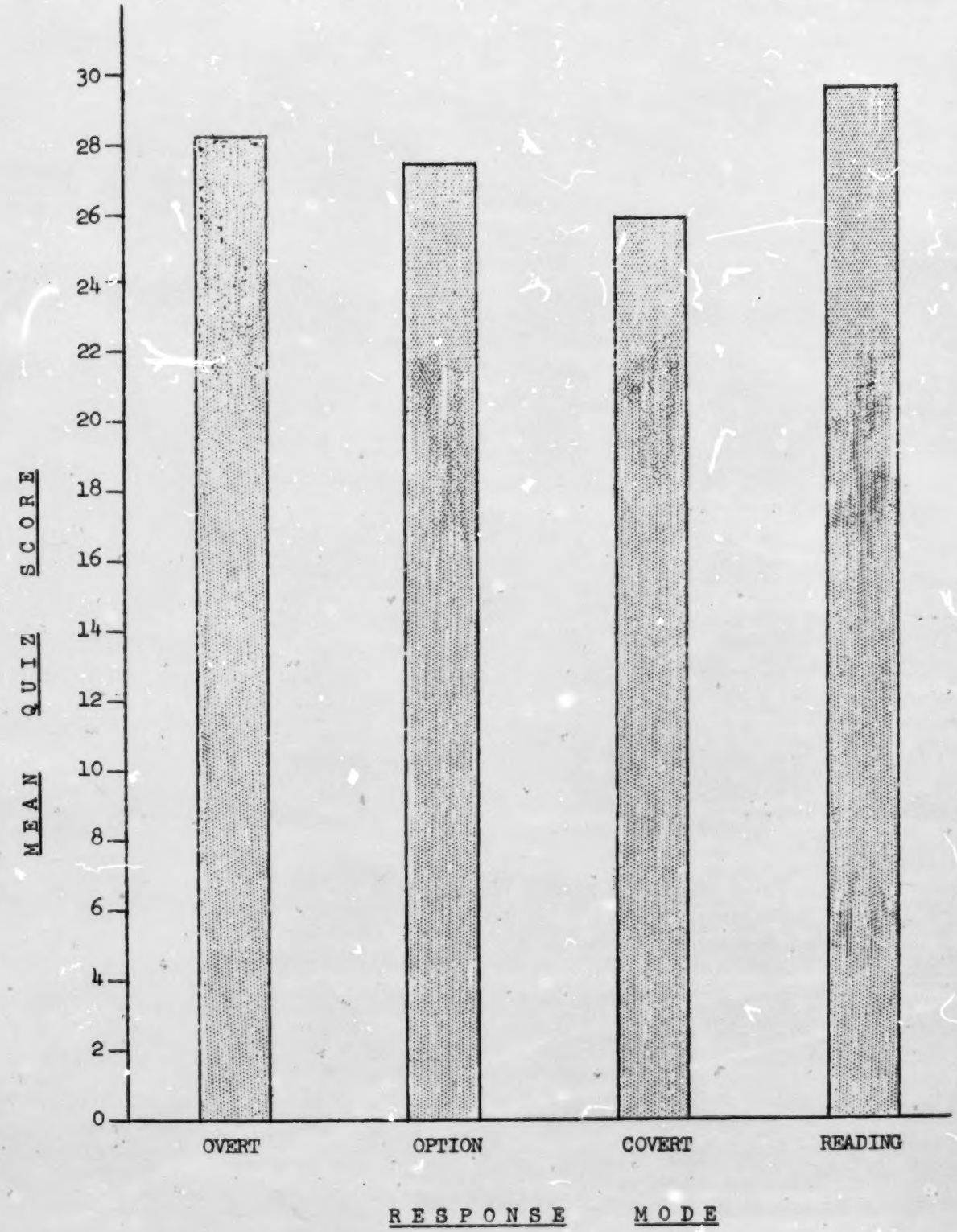

Figure 1. Mean Quiz Scores Adjusted by SCAT Reading Scores.

work habits between the classes. The mean difference between the classes on the reading scores of the School and College Ability Test (SCAT) was negligible, as noted earlier.

Of primary interest are the differences among response mode conditions. The reading scores from SCAT were used in a co-variance analysis of quiz scores to obtain a more sensitive and controlled test of response mode differences. The average within-cell correlation between the reading scores and quiz scores was found to be .54. Adjusted mean quiz scores for response mode conditions are shown in Figure 1. The co-variance analysis produced no significant difference among response modes ($F = 2.19$, d.f. = 3,53). The adjusted means show a slight superiority for the reading mode over the overt mode. The covert mode produced the poorest results, and the option mode fell between the overt and covert modes. It is not surprising that the mean for the option mode fell between the overt and covert means, in that the option mode has some of the operational characteristics of both of these other modes.

Relationship between Learning Responses and Quiz Responses

The sixteen Ss in the overt response group provided data bearing on the relationship between learning-response scores and quiz scores. The correlation between these two measures was found to be .49, which approaches significance at the .05 level of confidence. While this correlation indicates a reasonably substantial relationship between performance on the learning program and performance on the quiz, it obviously does not approach the level of a reliability coefficient; that is, we do not have two equivalent measures of how much has been learned.

Learning Time

In evaluating the effectiveness and characteristics of a condition of learning, the amount of time required for learning is as relevant a measure as amount learned. Ss in the present study were allowed to work through the learning program only once at their own rate of speed, thereby providing a measure of the effects of response mode conditions on learning time.

Since the average within-cell correlation between learning time and SCAT reading scores was negligible (r = -.21), no analysis of co-variance or adjusted mean learning times are reported. Table 2 presents the analysis of variance performed on the learning time data.

Table 2

Analysis of Variance Summary for Learning Time Data

Source	d.f.	mean square	F
Response Mode	3	313	26.08**
Class	1	79	6.58*
R X C	3	0	--
Within	54	12	--

* P < .05

** P < .01

The response mode difference is highly significant and the class difference is also significant. It should be recalled that the class difference approached significance for the quiz score data. It is relevant that the class which had the longer mean learning time also had the higher mean quiz score. While this might lead to the expectation of a sizeable

correlation between learning time and quiz score, such is not the case. The correlations between learning time and quiz score for the overt, option, covert and reading response mode groups, respectively, are as follows: -.31, .16, .27, and -.09 (all negligible). There are two possible factors which would operate in opposing directions to cancel out any correlation. A general ability factor would result in shorter learning times being associated with higher quiz scores to produce a negative correlation. On the other hand, shorter learning times may have been partly indicative of lower motivation and effort, tending to produce a positive correlation. The net result of these two factors may account for the failure to observe any sizeable relationship between learning time and quiz scores. This same rationale may account for the negligible relationship between learning time and learning score for the overt response mode group ($r = -.06$).

The mean learning times for the four response mode groups are plotted in Figure 2. These means show a decreasing trend corresponding to decreased explicit requirement to respond actively, i.e., to write or to think of responses. Using the analysis of variance error term with d.f. = 54 to test for differences between means, the overt mode and option mode difference is far short of significance ($t = .72$), while the covert mode and reading mode difference is of borderline significance ($t = 1.80$, $P < .10$). The difference between the option mode and covert mode is highly significant ($t = 4.65$, $P < .01$), and therefore, all remaining mean differences must be significant beyond the .01 level of confidence. It is apparent that the outstanding factor in producing a learning time difference was response writing. It is likely that at least a substantial portion of this time difference was attributable to the time spent actually writing responses.

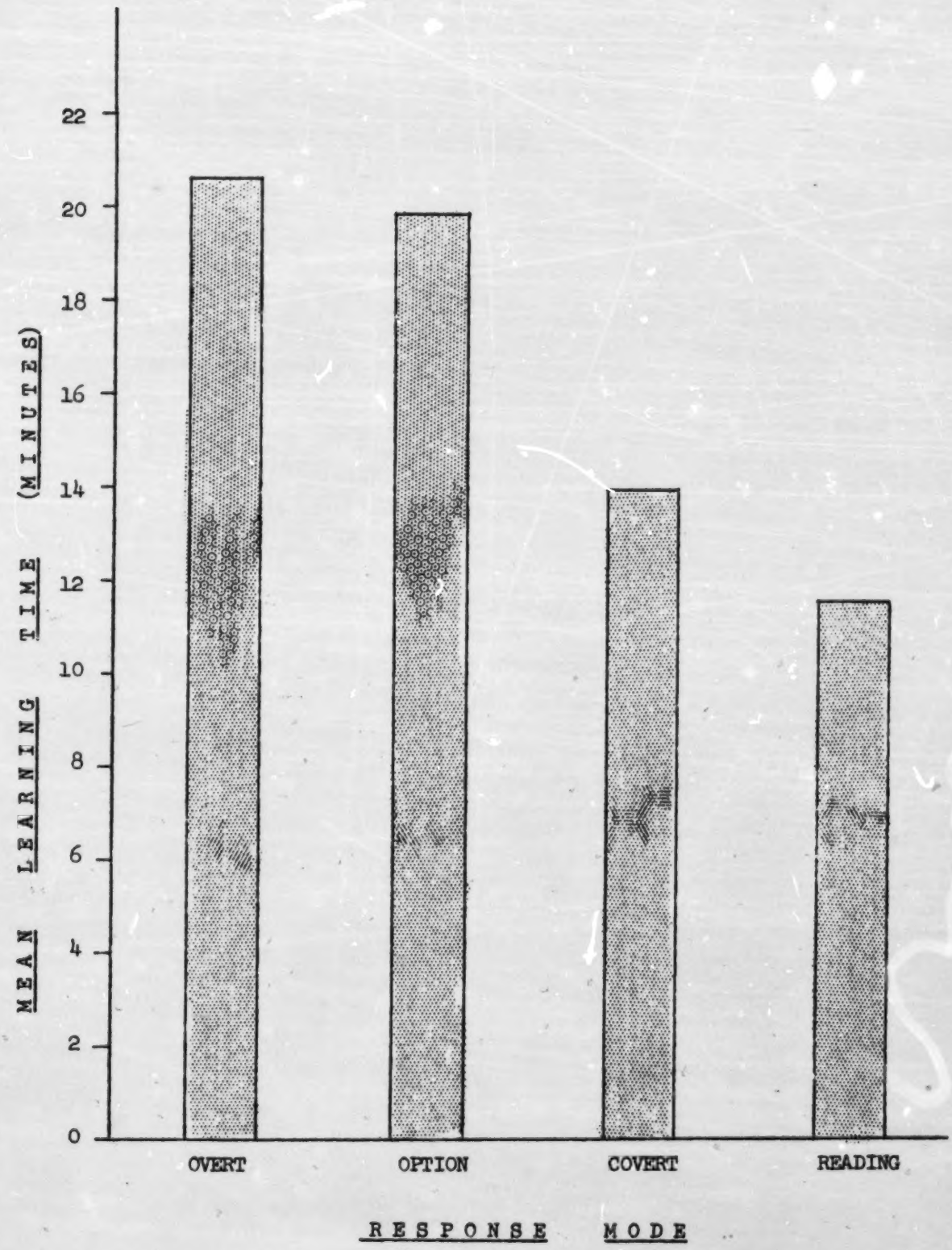

Figure 2. Mean Time to Complete the Learning Program.

The observed difference between the mean time for the covert and reading groups, as well as the magnitude of the differences between those groups and the overt group, suggests that time differences among response mode conditions deserves further study with writing time controlled.

Learning Efficiency

In order to obtain a measure which is sentitive to both amount learned and the time required to achieve the learning outcome, a score was calculated for each S by dividing his quiz score by his learning time score. This ratio of amount learned per unit of learning time was taken as an index of learning efficiency.

An analysis of variance for learning efficiency data, presented in Table 3, shows a highly significant difference among response mode conditions.

Table 3

Analysis of Variance Summary for Efficiency Score Data

Source	d.f.	mean square	F
Response Mode	3	6.50	9.85*
Class	1	.15	--
R X C	3	.11	--
Within	54	.66	--

* $P < .01$

In performing the analysis of co-variance on these data using the SCAT reading scores, the class variable was collapsed because of the negligible amount of variance attributable to this variable. The co-variance analysis produced an even higher value of F for the response mode variable ($F = 13.39$, $P < .01$ for d.f. = 3, 57). The average within-group correlation

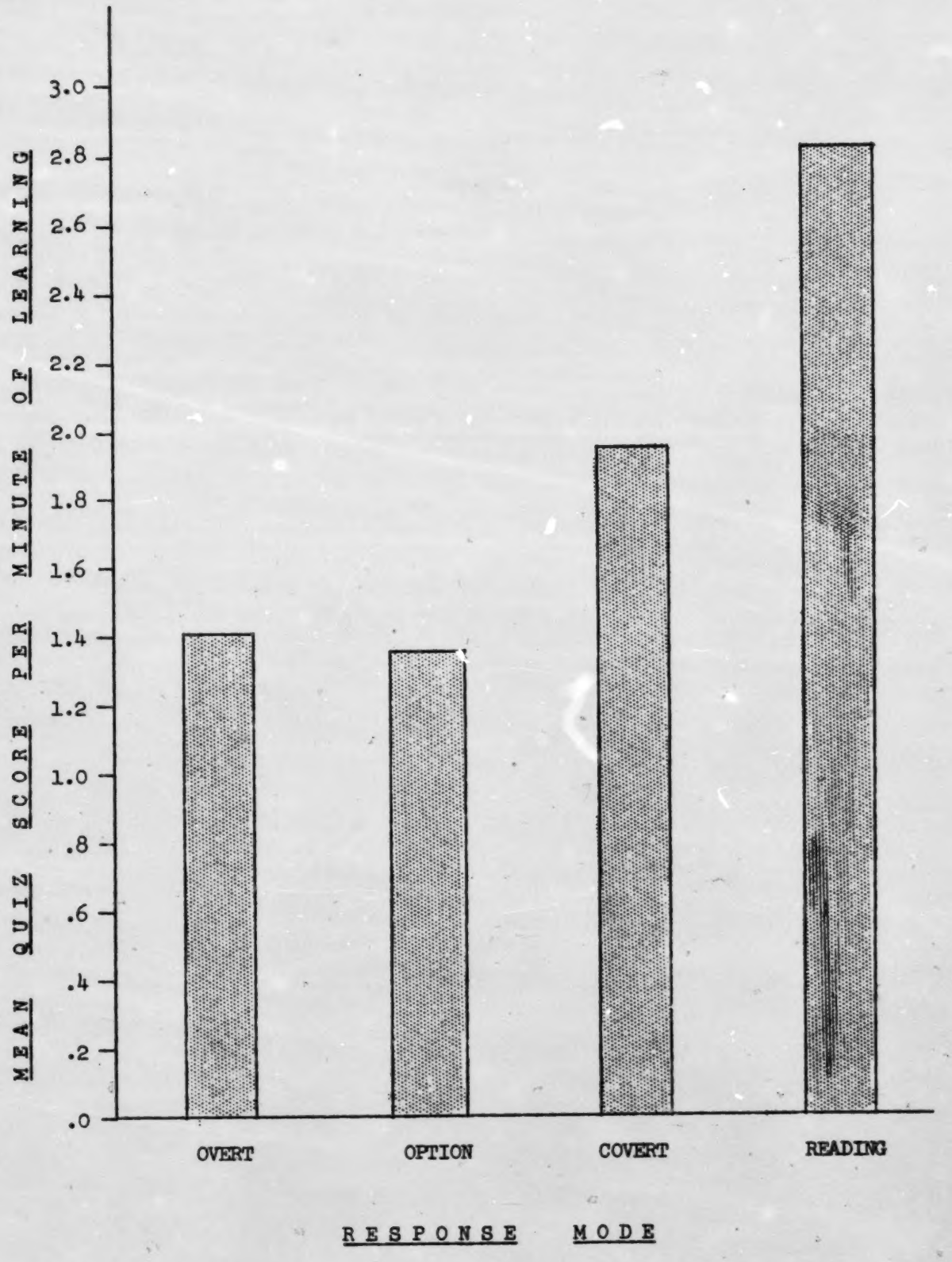

Figure 3. Mean Efficiency Scores Adjusted by SCAT Reading Scores.

between reading scores and efficiency scores was found to be .45.

Adjusted mean scores for response mode groups are plotted in Figure 3. The high efficiency level for the reading mode, the low efficiency level for the overt mode, and the intermediate efficiency for the covert mode is a finding which closely parallels the results from the previous study in this series using independent frames (Goldbeck, 1960). Using the co-variance data with d.f. = 57 to test adjusted mean differences (Lindquist, 1953), $t = 3.30$, $P < .01$ for the reading and covert response mode difference and $t = 2.13$, $P < .05$ for the covert and overt response mode difference. The reading mode was clearly the most efficient learning condition, while the overt and option modes which employ written responses were found to be the least efficient learning conditions.

Quiz Time

It is appropriate to consider whether the experimental conditions had any effect on the time taken by Ss to complete the quiz. The analysis of variance presented in Table 4 shows a significant difference among response modes, as well as a significant difference between classes.

Table 4

Analysis of Variance Summary for Quiz Time Data

Source	d.f.	mean square	F
Response Mode	3	46	4.18**
Class	1	55	5.00*
R X C	3	5	--
Within	54	11	--

* $P < .05$

** $P < .01$

The mean quiz times for the overt, option, covert, and reading response modes were 10.3 minutes, 12.0 minutes, 13.4 minutes, and 14.3 minutes, respectively. It is striking that the order of these quiz times is exactly inverse to the order of learning times. It is possible that this result was produced by the group situation under which the experiment was conducted. Ss may have become aware that they were ahead of or behind the other members of the class as a result of learning time differences associated with response mode conditions, and some Ss may have attempted to compensate for this time difference by time spent on the quiz. Another possibility is that writing responses during learning and perhaps thinking of responses increased the facility to write answers during the quiz, as measured by the time needed to complete the quiz.

Discussion

The most clear-cut finding from this study is the high learning efficiency found for the reading condition. This finding is in agreement with the learning efficiency results from Technical Report No. 1, in which independent frames, rather than continuous discourse frames, were used, thereby extending the generality of those results. In both studies, the overt response mode produced a relatively low level of learning efficiency, and the covert response mode resulted in an intermediate level of learning efficiency. The option response mode in the present study was nearly equivalent to the overt response mode in learning efficiency. This is not surprising, since the option group did not frequently exercise the option to omit an overt written response.

The question of why the reading mode has been found to be most efficient can be answered in general by considering that the motivation and set for an active pattern of learning can be established by presenting learning material in short logical steps (frames) that are interestingly written with an orientation for student responding. The further question of whether this mode of auto-instructional programming can maintain its high level of efficiency over long periods of time needs further investigation. Techniques used in the present study such as underlining important words, phrases, etc., establishing "attention-getting" relationships among frames, and employing short tests at appropriate intervals may be sufficient to maintain learning efficiency. Other techniques such as posing stimulating questions that will be answered by a block of subsequent frames, and varying the format of the program, may be pertinent to maintaining efficiency. The development and use of such techniques may also be found to increase the overall level of learning efficiency.

A more analytic consideration of learning efficiency involves the recognition that efficiency is derived from the two components amount learned and learning time, as measured in the present study. Any response mode condition of learning which produces (or shows potential for producing) a high amount of learning without a concomitant long learning time, or a condition which results in (or shows potential for resulting in) a short learning time without a concomitant low amount of learning is worthy of attention for possible further investigation. Each of these alternatives contributes to efficient learning, and it is possible that a particular training situation will require an emphasis on learning time, while another training situation will require an emphasis on amount learned. Naturally,

our ultimate goal is to identify factors which would enable the development of auto-instructional programs with the characteristics for maximum rate of learning, i.e., high amount of learning and short learning time.

In the present study, there was little variability among response mode means for amount learned as measured by the quiz score data. The mean for the reading group was slightly higher than the overt response group mean. The covert group mean was lowest. The expectation was not confirmed that, with a moderately difficult continuous discourse program, overt responses might show an advantage in absolute amount learned. However, these results are not inconsistent with previous findings that overt constructed responses during programmed learning do not produce higher performance on a subsequent quiz over the material.

In regard to the relationship of quiz scores to efficiency, it is apparent that, while the observed quiz score difference in favor of the reading mode over the covert mode contributed somewhat to the efficiency score advantage of the reading mode over the covert mode, quiz score differences had little effect on the reading mode efficiency advantage over the option and overt response modes. And, the low quiz score mean for the covert mode acted to attenuate the efficiency advantage of the covert mode over the option and overt response modes.

It would seem that the more substantial contribution to efficiency differences were made by learning time differences. The greatest difference in learning time scores was found between the response modes requiring written constructed responses (the overt and option modes) and the modes requiring no written responses (the covert and reading modes). The superior efficiency of the reading mode over the option and overt modes is clearly

the result of the short learning time for the reading mode as compared to the relatively long learning times for the overt and option modes. Any attempts to increase the learning efficiency of the latter response mode conditions which required constructed responses must consider procedures which would reduce the writing time involved in the performance of constructed responses.

The superior efficiency of the reading mode over the covert mode is not so clearly dependent solely on a learning time difference, since the learning time advantage of reading over "thinking" is of a lower magnitude, and only marginally significant. It is relevant to consider here, that the low observed quiz score mean for the covert group may be a result that is affected by the use of more than one "response" blank in many of the learning frames. Ss had to "think" of more than one response in these frames before receiving the feedback. This could have resulted in some confusion concerning which of the thinking responses in a frame was correct and might have had a detrimental effect on both quiz score and learning time.

The finding of a significant difference among response mode conditions on quiz time is relevant in regard to the effect of learning time differences. That long learning times were associated with short quiz times may have been a function of the group conditions under which the experiment was conducted. Nevertheless, if we include time to perform on the quiz as part of the time to be considered in determining efficiency, the obtained efficiency differences would be somewhat attenuated. This consideration is especially relevant in regard to the efficiency of the reading mode, since some form of test administration may be required as part of the instructional procedure, as it was in the present experiment.

It is indicated that further studies of the effects of time and response conditions are needed to determine the most efficacious conditions for auto-instructional procedures, especially in regard to the conditions which appear to make the reading mode a highly efficient method of learning.

Summary

An experiment was conducted to determine the effects of response mode differences on auto-instructional learning, using a continuous discourse program of moderate difficulty. Three of the four response modes investigated were similar to those used in a previous study using an auto-instructional program of independent-item frames. These three modes were overt response (S was required to construct a written response), covert response (S was required to think of a response), and reading response (S read the "response" which was underlined). The fourth response mode investigated was an option response mode (S could either construct a written response or omit the response, depending on his confidence in being correct.

A total of 62 Ss from two eighth-grade classes participated in the experiment. S completed a short practice program using his assigned response mode and also completed a short quiz on that material before beginning the experimental program. S completed the 32-frame experimental program covering the topic of light sources at his own rate of speed and was given an immediate quiz on that material.

No significant differences were found among response mode conditions on the quiz score criterion. The obtained mean for the reading mode was slightly higher than the mean for the overt mode. The option mode and covert mode means were somewhat lower, with the covert mode performing poorest.

Significant learning time differences were found among the four response mode conditions. The overt condition had the longest learning time, followed by the option mode, covert mode, and reading mode in that order. The greatest separation was produced by the requirement to construct written responses, resulting in relatively long learning times for the overt and option modes.

Learning efficiency scores were obtained by dividing quiz score by learning time for each S. According to this criterion, the reading response mode was significantly more efficient than any of the other response modes. The covert response mode was significantly more efficient than the overt and option modes, the latter two modes showing negligible difference.

The results of this study using continuous discourse material are in general agreement with the findings from the previous study using independent-item frames, lending generally to the hypothesis that requiring written constructed responses to easy items is not an essential condition for effective learning. The results are discussed in terms of the conditions which contribute to active responding and efficient learning, with special emphasis on the reading mode of responding to programmed material.

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